Heart Rate Response to Suctioning in Neonates on Nasal Continuous Positive Airway Pressure

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Abstract

Placing respiratory compromised neonates on Nasal Continuous Positive Airway Pressure (NCPAP) is becoming a more popular method of ventilation than other options, such as mechanical ventilation. The estimated number of infants affected by respiratory distress syndrome is between 20,000 and 30,000 infants per year and these infants are commonly placed on NCPAP. There is currently no existing evidenced-based practice for suctioning procedures for neonates on NCPAP. The accuracy and timeliness of the nurse assessing and determining the need to suction to maintain the airway of the neonate is crucial as to whether or not the NPCAP will be successful. The lack of evidence in suctioning NCPAP neonates has led to discontinuity across NICUs performing this procedure. The purpose of this study is to characterize the variability in heart rate when suctioning neonates on NCPAP. A descriptive design will be used to study 15 recruited NICU babies on NCPAP from the Ohio State Wexner Medical Center. This is a descriptive pilot study where data will be collected from observing infant clinical and behavioral responses to typical care while on Bubble NCPAP. Heart rate, respiratory rate, and oxygen saturation observations will be recorded 5 minutes pre-suctioning, during suctioning, immediately after suctioning, and 10 minutes after suctioning or return to 10% of the neonate's baseline physiological parameters. The neonates PIPP score will be evaluated prior to suctioning and after the suctioning care. Descriptive analysis will be used to determine the neonates heart rate changes and to categorize these changes by type and gestational age. We hope that this project will provide a basis of knowledge for prospective solutions for decreasing heart rate variability in neonates on NCPAP.

Chapter I

Introduction

Among neonates experiencing respiratory distress or upper airway obstruction, the NCPAP is gaining popularity as a means of respiratory support. NCPAP use across NICU's has been growing because it is much less invasive when compared to other respiratory support options that require mechanical ventilation and endotracheal intubation (Bonner & Mainour, 2008). The NCPAP pumps air under pressure into the neonate's airway, keeping their airway open to maintain functional residual capacity. This prevents the airway from collapsing and blocking the neonate from being able to breath.

The current issue with utilizing the NCPAP on neonates is that there is no evidence to support the best way to care for neonates on this device. Within and across NICU's, there is currently a wide variation in NCPAP practices including nurse's decision-making factors concerning how often neonate's need to be suctioned and what the best technique is for suctioning (Mann, Sweet, Buck, & Chipps, 2013). With nasopharyngeal suctioning and manipulation of the NCPAP prongs already being the most painful procedures in the NICU, these findings are of great concern because variations in practice are often associated with less favorable outcomes for the neonate (Cignacco et al., 2009; Mann et al., 2013).
With NCPAP gaining popularity in NICU's, guideline's need to be developed to minimize unfavorable outcomes for the neonates.

By assessing the changes in the neonate's heart rate during suctioning events, we can more effectively evaluate the best practice for neonates on NCPAP. This project seeks to examine the effects suctioning on the NCPAP can have on neonates based on their gestational age. At this time, no existing research studies have examined this specific topic or provided evidence for best practices for neonates on NCPAP. The specific aim of this study is to:

- To characterize the variability of heart rate responses to suctioning neonates on nasal continuous positive airway pressure based on their gestational age.

Chapter II

Literature Review

The estimated number of infants affected by respiratory distress syndrome is between 20,000 and 30,000 infants per year (Bonner & Mainour, 2008). The respiratory support system neonates with RDS are commonly placed on is the nasal continuous positive airway pressure (NCPAP) (Mann et al., 2013). The accuracy and timeliness of the nurse assessing the neonate is crucial as to whether or not the NPCAP will be successful (Bonner & Mainour, 2008). Complications can be avoided or minimized if caretakers remain alert for changes in the neonate's status, enabling early interventions (Bonner & Mainour, 2008). Although immense improvements in treating respiratory distress have occurred by using NCPAP, there is still no evidence to support the best practices for suctioning infants on NCPAP (Mann et al., 2013). An earlier survey study of neonatal RNs revealed that suctioning practices among caregivers were highly variable in the NICU (Mann et al., 2013). The lack of evidence in suctioning NCPAP neonates has led to discontinuity across NICUs performing this procedure. One particular physiological parameter whose response to suctioning needs to be examined for best practice is heart rate variability.

Prior to Gregory and associates introduction of continuous positive airway pressure in 1971, neonates born with respiratory distress syndrome in the United States often died (Sherman, Blackson, Touch, Greenspan, & Shaffer, 2012). Nasal continuous positive airway pressure (NCPAP) has grown popular because of its association with a decreased need for re-intubation and decreased overall incidence of broncho-pulmonary dysplasia in neonates (Mann et al., 2013). The CPAP is also becoming a very attractive choice of therapy as it has helped significantly decrease the mortality rate (Sherman et al., 2012). With the increasing number of premature infants surviving, we need to continuously address their respiratory requirements (Bonner & Mainour, 2008). Most importantly we need to establish nationwide policies for suctioning these infants on CPAP.

There are few studies which describe NCPAP suctioning frequency and technique needs to be addressed, especially because suctioning is among one of the most frequently performed procedures in the NICU (Mann et al., 2013). Although no evidence exists for suctioning infants on NCPAP, neonatal behavioral and physiological responses have been examined for endotracheal tube (ETT) suctioning and mechanical ventilation (MV) suctioning. As one of the most frequent and distressing practices done in the NICU (Barbosa, Cardoso, Brasil, & Schochi, 2011), many studies have assessed the changes in the neonate's physiological parameters, such as the pain response, with ETT suctioning. ETT suctioning is a stressful stimulus that puts infants at risk for multiple complications, including "hypoxemia, bradycardia, tachycardia, atelectasis, pneumonia, fluctuations in blood pressure and intracranial pressure, localized trauma to the airway, pneumothoraces, tube blockage, and extubation" (Cone, Pickler, Grap, McGrath, & Wiley, 2013). The disturbance and edema to the nares and nasopharynx caused by frequent avoidable suctioning is also a large potential risk for neonates on NCPAP (Mann et al., 2013). Examining the neonate's pain response is vital to their development because of how frequently suctioning occurs as well as how much of a disturbance it can physically cause to the neonate.

One of the reasons the NCPAP is successful is that it allows neonates to spontaneously breathe without the help of a mechanical ventilator (Sherman et al., 2012). Studies show that infants treated with NCPAP have the "best outcomes for low birth weight infants and the lowest incidence of chronic lung disease" (Sherman et al., 2012). Use of the NCPAP has many benefits, including that it is less invasive than other respiratory support systems (Bonner & Mainour, 2008). Infants utilizing NCPAP are known to be extubated earlier, and to have a reduction in incidence, duration, and difficulties of intubation and mechanical ventilation (Gittermann, Fusch, Gittermann, Regazzoni, & Moessinger, 1997).

Neonates undergoing painful procedures like suctioning are at risk for pain. According to Mosby's Skills Neonatal Pain Assessment (2014), physiologic cues the neonate is in pain may include "changes in heart rate, respiratory rate, oxygen saturation, blood pressure, and palmar sweating" (Ackley, Ludwig, & Rogers, 2006). Mosby's also states "behavioral pain cues may include altered facial expressions, body movements, and crying" (Ackley et al., 2006). With such broad indications of pain, it can be easily undetected or attributed to other stimuli. Premature neonates are at risk for acute and prolonged pain for various other different reasons. When compared to full-term neonates, very low birth weight (VLBW) neonates behavioral response to pain is much fainter and can go undetected (Padhye, Williams, Khattack, & Lasky, 2009). Another reason pain goes unnoticed in the NICU is based on how frequently pain is assessed and the chance that prolonged pain might be unrecognized and untreated in newborns (J. De jonckheere et al., 2011). The long-term effects of pain may include "increased intracranial pressure; depressed immune response; and altered neurodevelopmental, social, and emotional function" (Ackley et al., 2006).

Routine care in the NICU, inserting feeding tubes, mechanical ventilation, and nasal injuries during NCPAP, are possible causes of prolonged pain in neonates (J. De jonckheere et al., 2011). Earlier studies demonstrate a clear relationship between the systems regulating cardiovascular functions and the systems associated with pain perception (J. De jonckheere et al., 2011).

The population of neonates placed on NCPAP is extremely vulnerable because of their physical immaturity and the environmental factors of the NICU that affect their body systems. Studies demonstrate that suctioning puts infants at risk for bradycardia, cardiac dysrhythmias, and cardiac arrest (Mann et al., 2013). These factors are especially important to study in neonates on NCPAP considering that extreme low birth weight neonates have trouble regulating external stimulus because of their immature neurologic systems (Tan et al., 2005). The inability to regulate external stimulus often results in “autonomic compensations, which involves physiological responses such as hypoxemia and bradycardia” (Tan et al., 2005, p. 235). Researchers suggested that infants could respond to a painful stimulus with bradycardia and short-term inhibition of the sympathetic nervous system (J. De jonckheere et al., 2011). Researches have also found that “the stressful NICU environment can cause initial increases in HR in acutely ill infants” (Peng et al., 2009).

One study by Slevin (1998) found that during endotracheal suctioning of the neonate, heart rate levels changed significantly leading to an “increased physiological instability in terms of heart rate stability during suctioning”. This same study discusses how health care workers have observed bradycardia during suctioning and how the infant’s heart rate dropping during suctioning was followed by an immediate increase following the procedure (Slevin et al., 1998). One study that measured heart rate pre-, during, and post-endotracheal suctioning found there was a significant change in the median heart rate. This study found that the heart rate variability increased significantly throughout endotracheal suctioning leading to increased physiological instability (Slevin et al., 1998). However, other studies have found a decrease in heart rate variability (HRV) during painful procedures such as heel lance procedures, (Padhye et al., 2009

& De Jonckheere et al., 2011). The diminutive amount of literature that does exist about neonatal heart rates during suctioning does not come to similar conclusions.

Taking into account the vulnerability of the population on NCPAP and the effect suctioning has on heart rate, several studies have examined the heart rate variability. Measuring HRV offers quantitative information of the neonate's autonomic state (Padhye et al., 2009). HRV has progressively become a popular tool for measuring stress and neonatal health, which implies that it can be a helpful measure of reactivity to painful events in ill preterm infants who are able to mount only nonspecific and ambiguous behavioral distress signals" (Padhye et al., 2009). One study demonstrated that "a higher variability in HR over a shorter period may translate to cardiac output and blood pressure fluctuations, which may contribute to adverse cerebral hemodynamic sequel" (Tan et al., 2005). The same study found that episodic bradycardia in preterm neonates is associated with obstructive type apneic events, such as endotracheal suctioning (Tan et al., 2005). The same study stated "episodic hypoxemic and bradycardic events have been implicated, individually or in combination, in cerebral heomodynamic fluctuations that can lead to the development of serious cerebral morbidities" (Tan et al., 2005). These findings reflect the need for evidenced based practice guidelines to help health care providers properly assess these parameters and reduce NCPAP suctioning complications.

Chapter III

Methods

Design

This is a descriptive pilot study where data will be collected from observing infant clinical and behavioral responses to typical care on Bubble NCPAP. To serve as their own controls, a repeated measures design will be used within-subjects (See figure 1). (Aim 1 and Aim 3)

In order to describe variability in neonatal responses to suctioning, data will also be examined. (Aim 2)

Setting

This research study took place at The Ohio State University Wexner Medical Center in the Neonatal Intensive Care Unit (NICU). This unit, on 6 Doan, specializes in neonates requiring critical care specialists.

Sample

Based on the inclusion criteria, a convenience sample of 15 neonates from the NICU at The Ohio State University Wexner Medical Center (OSUWMC) will be enrolled in this study. OSUWMC's NICU is a Level III 49 bed unit that takes in about 1100 neonates each year. The inclusion criteria for neonates includes: (1) neonates on Bubble NCPAP, (2) gestation of 27-32 weeks, (3) are older than 3 days of life but younger than 7 days of life, (4) have a representative that is legally authorized, (5) are clinically stable as described by the NICU care team. Criteria that would exclude a neonate include: (1) presence of any cranial/facial malformations, (2) chromosomal/genetic anomalies, (3) congenital heart disease, (4) placement of a chest tube, (5) persistent pulmonary hypertension, (6) receiving any treatments or medicine that changes the pain response such as narcotics, paralytics or other sedatives.

Measures

The heart rate (HR), respiratory rate (RR), oxygen saturation (PaO2), and Premature Infant Pain Profile (PIPP) will be measured in each neonate prior to the painful event and within 30 seconds of the painful event. Health and demographic data collection will include primary diagnosis, nursing acuity score, gestational age, birth age, birth weight, and gender.

Instrument

The Premature Infant Pain Profile (PIPP) Score and HR. The PIPP is a scale designed to measure the behavioral measure of pain in infants. The scale is made up of seven indicators including behavioral state, heart rate maximum, gestational age, brow bulge, eye squeeze, oxygen saturation, and nasolabial furrow. Each of the seven indicators has a possible score ranging from 0-3. Scores are added up from all indicators ranging from 0-21 with high scores indicating more pain. The PIPP has excellent interrater reliability (0.93-0.96) and intrarater reliability (0.94-0.98). The PIPP also has an established validity (Ballantyne, Stevens, McAllister, Dionne, & Jack, 1999; Stevens, Johnston, Petryshen, & Taddio, 1996).

Data Collection Procedure

Subsequent to consent, collection of demographic and medical information will be taken from the electronic medical record. The Clinical Nurse Specialist (CNS) and two senior staff NICU RN's served as the study RNs in order to reduce the variability in suctioning technique and response. A focus group including the CNS and the two senior staff RNs participating in the study verified reliability on the guidelines for suctioning that is currently used as the standard of care, and they will follow through with NCPAP suctioning at the times of usual care. The collected data will be coded for the particular RN providing suctioning and this data will be used as a variable in analysis of Research Aim 2 (characterization of variability in neonatal suctioning response). In order for observations to occur only during naturally occurring suctioning occasions, the assigned caregiving RNs will alert the study RN during selected “care times” as decided by the caregiving RN. Random selection of suctioning events is not practical in this descriptive study because of how rarely NICU suctioning events occur during designated care times.

As a team, the study RNs, study evaluators, and the caregiving RN will determine and record the beginning of each pre-suctioning period. The study RN will start the suctioning procedure. At the start, the study evaluator will document the neonate’s heart rate (HR), respiration rate (RR), and oxygen saturation. Whether oral or nasal, each suctioning pass will be perceived as a single event. The study evaluator will record the HR, RR, and oxygen saturation again when suctioning is completed. The final recording of the HR, RR, and oxygen saturation will occur either 10 minutes post suctioning procedure or when the neonate has returned to within 10% of baseline physiological measures.

The suctioning method used for this study is the agreed upon “best practice” on the routine normal care as determined by the nursing clinical experts of the OSUWMC NICU. The nurse will assess the neonate suctions needs and then place the infant on a Z-flo™ or Snuggle-Up™ positioner to keep the neonate in a flexed position. Before suctioning, blow by oxygen will be increased by 5-10% to increase oxygen concentration. The neonate’s weight will determine the suctioning catheters size. The suction will be set to use the lowest amount of necessary pressure (between 60-100 mm Hg) to eliminate secretions. While pulling out the suctioning catheter for 5-10 seconds, the suction is applied. Lubricant can be used for nasopharyngeal suctioning catheters.

As outlined in the agreed upon protocol, the study RN will carry out the suctioning event. One of the two trained study evaluators will record observations 5 minutes pre-suctioning, during suctioning, immediately after suctioning, and 10 minutes after suctioning or return to 10% of the neonate's baseline physiological parameters.

Table 1

Measures

	5 minutes Pre-Suctioning	**During Suctioning**	**Immediately after Suctioning**	**Post-suctioning (10 minutes post/return to baseline)**
Heart Rate	X	X	X	X
Respiratory Rate	X	X	X	X
Oxygen Saturation	X	X	X	X
PIPP Score	X			X
Time (seconds) to return to 10% of baseline parameters				X

Data Analysis

Descriptive analysis was used to evaluate the collected data. Each suctioning event heart rate was compared to the neonate's baseline heart rate. Heart rate changes were categorized by heart rate elevation with each event and heart rate depression with each event. The gestational age of the neonate for each category was compared. Using correlational analysis, the relationship between heart rate changes with each event and the gestational age of the neonate were examined.

Chapter IV

Results

The study is still in progress and these results reflect an interim analysis. The sample size for the current analysis is small. A total of 11 neonates that fit the inclusion criteria were consented and utilized for this study. Subject 2 was not included in the data because they were removed from NCPAP after signing consent. Subject 3 and Subject 5 were not included in this data because nasal suctioning was not indicated for these neonates. Subject 9 was not included because there is no gestational age on file for this neonate. This analysis reflects a total of 7 neonates. See Table 2 for collected heart rate variability during suctioning data

Table 2

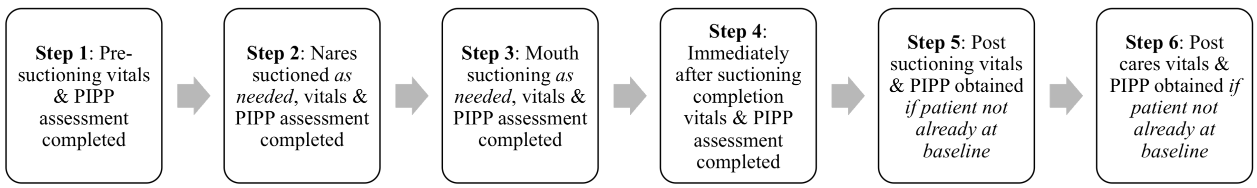
Heart Rate Variability During Suctioning

Subject	GA	Pre Sxn	R Nare 1	R Nare 2	L Nare 1	L Nare 2	Mouth 1	Mouth 2	Mouth 3	Immediately after sxn	Post sxn	Post Cares
Subject 1	28 and 5	151	121	-	122	-	134	160	-	126	158	-
Subject 3	27 and 6	165	-	-	-	-	169	-	-	-	167	166
Subject 4	27 and 6	160	184	-	178	-	185	189	172	188	164	166
Subject 5	27 and 6	166	-	-	-	-	152	118	-	185	164	156
Subject 6	28 and 4	162	163	-	169	-	165	-	-	170	169	163
Subject 7	31 and 0	173	156	-	158	-	138	-	-	151	159	174
Subject 8	29 and 3	162	164	-	154	170	174	-	-	175	151	146
Subject 9	-	155	159	160	163	165	163	-	-	159	161	170
Subject 10	31 and 6	147	144	-	144	-	144	136	-	153	150	141
Subject 11	30 and 3	169	146	-	141	-	166	180	171	183	169	-

The heart rates collected for each subject during each event (Figure 1) were compared to the subject's baseline heart rate. Using descriptive analyses, it was noted that all of the neonate's heart rates varied from their pre-suctioning baseline (Step 1) heart rate during each procedure. All of the neonate's heart rates returned within 10% of pre-suctioning baseline heart rate post-suctioning or post-cares (Step 5 and Step 6). Data from subject's whose heart rate increased from baseline during each suctioning event were analyzed separately from subjects whose heart rate decreased during each suctioning event.

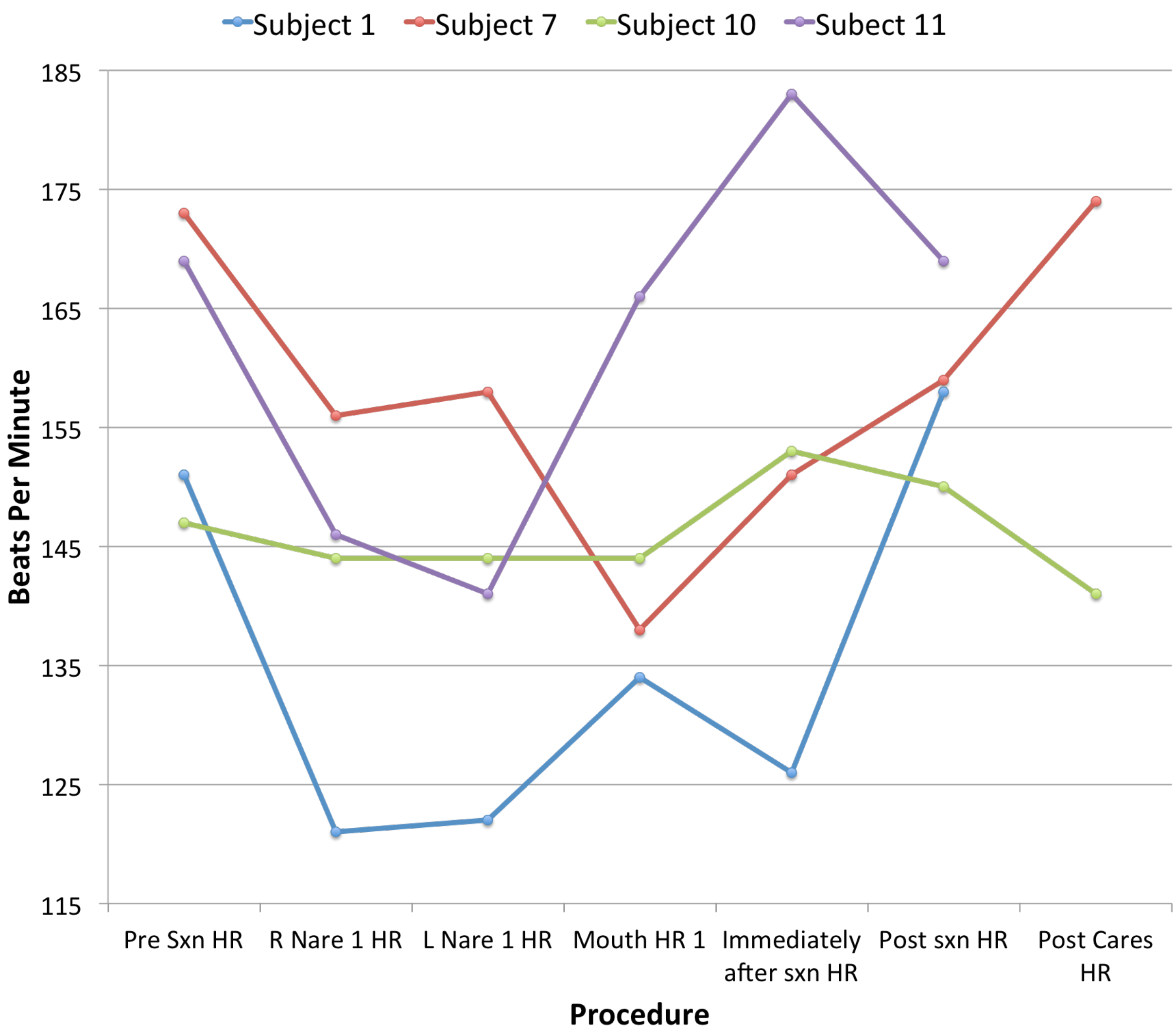
Figure 1

Procedures



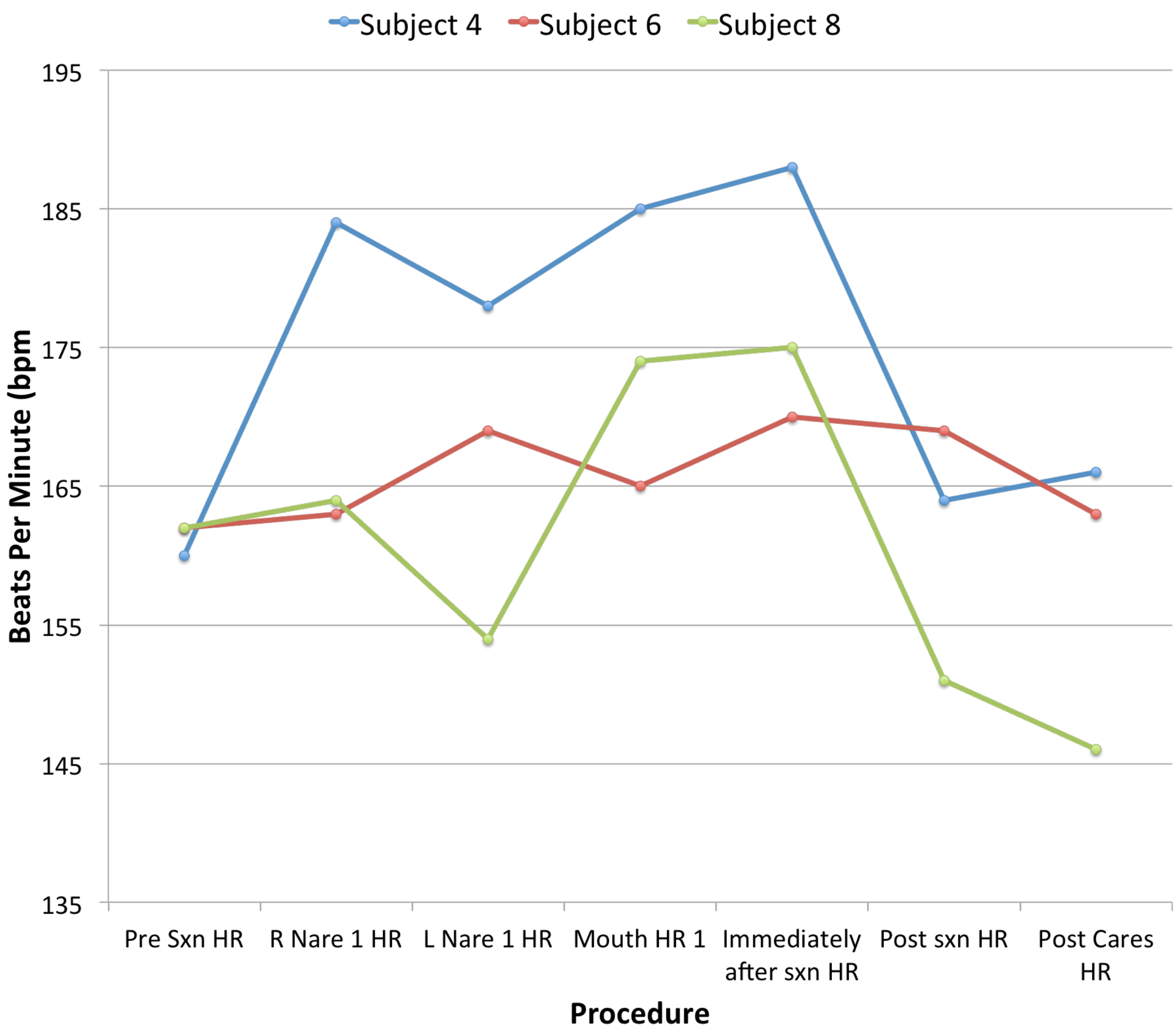
Four out of 7 neonates who needed both nasal and oral suctioning demonstrated heart rate depression below pre-suctioning baseline during the first pass of each suctioning procedure (Step 2 and Step 3). The first pass only includes the first suction event of each orifice. The neonates that demonstrated heart rate depression during suctioning were of older gestational ages compared to those who did not show heart rate depression upon suctioning. The following subjects and gestational ages exhibited heart rate depression: Subject 1 (28 weeks and 5 days), Subject 7 (31 weeks and 5 days), Subject 10 (31 weeks and 6 days), and Subject 11 (30 weeks and 3 days). Figure 2 illustrates these findings.

Figure 2: ***Heart Rate Variances in Subjects 1, 7, 10, & 11***



The remaining three out of the 7 neonates who required both nasal and oral suctioning demonstrated heart rate elevation above pre-suctioning baseline during the first pass of each suctioning procedure (Step 2 and Step 3) with the exception of subject 8 during the first left nares pass (Step 2). These neonates were of younger gestational ages when compared to the neonates who experienced heart rate depression during suctioning. The neonates who displayed heart rate depression included Subject 4 (27 weeks and 6 days), Subject 6 (28 weeks and 4 days), and subject 8 (29 weeks and 3 days). Figure 3 illustrates these findings.

Figure 3: ***Heart Rate Variances in Subjects 4, 6, & 8***



The trends in the preliminary data suggest that neonates with older gestational ages experience bradycardia with painful suctioning stimuli and neonates with younger gestational ages experience tachycardia with painful suctioning stimuli. The data suggest that there is variability in heart rate of neonates during NCPAP suctioning based on their gestational age.

Chapter V

Discussion and Conclusion

The interim results from the collected data suggest that there is a high variability in neonatal heart rates based on gestational age. This finding of variability of neonatal heart rates supports the work of Tan (2005) in that the pre-term babies have trouble regulating the external stimulus of suctioning because of their immature neurologic systems. Their immature neurologic systems often cause autonomic compensations such as changes in heart rate with external stimuli (Tan et al., 2005).

This study also supports the work of Slevin's earlier study of neonatal heart rates during endotracheal suctioning (Slevin et al., 1998). Slevin (1998) found that there was a significant change in the median heart rate of neonate's when measuring their pre-, during, and post-endotracheal suctioning heart rate which is similar to the significant changes in baseline heart rate's found during pre-, during, and post-NCPAP suctioning found in this study (Slevin et al., 1998). Slevin's endotracheal suctioning study concluded that neonatal heart rate variability increased significantly throughout suctioning similarly to this study of NCPAP suctioning (Slevin et al., 1998).

The data collected differs from previous studies in that neonate's heart rates both increased and decreased with the painful stimuli of suctioning. Previous studies related to suctioning neonates on mechanical ventilation or with endotracheal tubes suggested that neonates more commonly tend to become bradycardic with suctioning due to short-term inhibition of the sympathetic nervous system (J. De jonckheere et al., 2011). Tan found that endotracheal suctioning of preterm neonates and other obstructive apneic events caused bradycardia (Tan et al., 2005). Although several of the neonate's became bradycardic during

NCPAP suctioning, some of the neonates demonstrated tachycardia during NCPAP suctioning. The variability in neonatal heart rates found during NCPAP differs from the bradycardia found during suctioning endotracheal tubes and mechanical ventilation.

This study differs from other studies for two important reasons. First off, there is currently limited research concerning neonates on NCPAP, let alone neonatal heart rate responses to suctioning on NCPAP. While studies show that pre-term infants commonly become bradycardic during suctioning of endotracheal tubes and mechanical ventilation, this study demonstrated variable changes in neonatal heart rates. There is also only a limited amount of existing research related to gestational age and heart rate variability during any type of suctioning.

The goal of this project was to characterize variability in heart rate response to suctioning neonates on NCPAP by gestational age. Our findings suggest that there is variability in neonate's heart rates during NCPAP suctioning based on their gestational age. With the increasing use of the NCPAP, a need for suctioning guidelines is needed to enhance short-term and long-term neonatal outcomes.

Limitations of this project include that the data collected is only from one NICU so it cannot be generalized to all NICU's. Another limitation is that it is a pilot study with a small sample size. The small sample of subjects does not fully capture the larger populations heart rate variations. The collected data cannot be extrapolated into trends or cause-and-effect relationships the way a longitudinal study might.

With the knowledge of neonatal heart rate responses to NCPAP suctioning, we are progressively able to develop evidenced-based practice suctioning guidelines that provide for the most favorable outcomes for the neonate. The significance of this study demonstrates that suctioning guidelines are necessary and should consider the gestational age of the neonates being suctioned.

To gain a better idea of the implications of neonatal heart rate variability during NCPAP suctioning, further research is necessary. Future studies should focus on developing a standardized suctioning technique as well as interventions to reduce undesired neonatal heart rate variance associated with suctioning. The suctioning technique and heart rate interventions should be studied by gestational ages. Longitudinal research can supply information about long-term effects of suctioning and examine causal relationships. Only with additional research can we obtain a clearer representation of the multivariable elements that characterize neonatal heart rate variability during NCPAP suctioning.

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